

"A New Method of Detecting Electrical Oscillations." By J. A. EWING, LL.D., F.R.S., and L. H. WALTER, M.A. Received January 11,—Read February 11, 1904.

The magnetic detector of Rutherford,* though now well known, appears to have created little interest until attention was directed to the subject by Marconi's adaptation of the method to his telephonic detector. Marconi's apparatus employs the change of hysteresis, which is produced in iron by the influence of electric oscillations, when these are caused to pass through a coil surrounding the iron, the change being made manifest by means of a telephone. In his view, the electric oscillations act by reducing the hysteresis.†

It occurred to us to exhibit the alteration in hysteresis by a different method, namely, by applying the principle which is used in an instrument invented some years ago by one of us for the mechanical measurement of hysteresis. In that instrument‡ the hysteresis is measured by the mechanical couple between a magnetic field and the iron, when either the iron or the magnet providing the field is caused to revolve. Thus, if the field revolves, the iron tends to be dragged after it, as a consequence of hysteresis in the reversals of its magnetism, and if the motion is prevented by a spring or other control, it assumes a deflected position. Suppose, now, the electric oscillations to act on it, any change of the hysteresis caused by them will be exhibited by a corresponding change in the deflection. We anticipated, in accordance with the generally accepted view that hysteresis is reduced by the oscillations, that their presence would be detected by a fall in the deflection.

With this expectation an experimental apparatus was arranged, consisting of an electro-magnet, capable of being rotated on a vertical axis by an electric motor. The magnet poles were bored out circular, and between them was suspended, by a phosphor-bronze strip, a ring made up of three thin, flat annuli of soft iron, clamped together, and provided at the foot with an axial pivot. The ring was free to turn inside of two bobbins wound with fine copper wire, the windings being at right angles to the plane of the ring. Through these copper windings, electrical oscillations, produced in the usual manner by means of a distinct spark-gap, were passed.

The first experiments resulted in a very small deflection from the position due to normal hysteresis, indicating, as was expected, a decrease of hysteresis when the oscillations arrived. The apparatus

* 'Phil. Trans., A, vol. 189, p. 1, 1897.

† 'Roy. Soc. Proc.,' vol. 70, pp. 341—344, 1902.

‡ 'Journ. Inst. Electr. Engineers,' vol. 24, pp. 398—430, 1895.

was also tested with an alternating current of about 100 periods per second in place of the oscillations, with the effect that the normal hysteresis deflection was almost entirely wiped out.

Various other forms were also tried with indifferent results, when it occurred to us that there would be advantages in passing the oscillations through the magnetic material itself, making it of magnetic wire. A small bobbin was therefore wound with insulated soft iron wire, and the ends soldered to the upper and lower halves of the spindle, which was itself divided at the centre, the upper half bearing the controlling spring, and the lower dipping into mercury, from which a connection led to the other terminal. On passing oscillations through this winding, a remarkable and unexpected result was obtained. The change of deflection was much more marked than in the former experiments, and was in the opposite sense, indicating an increase of hysteresis while oscillations were present. Afterwards, hard steel wire was substituted for the soft iron, and a very great increase in the effect was observed, still in the same direction—that of increase of hysteresis.

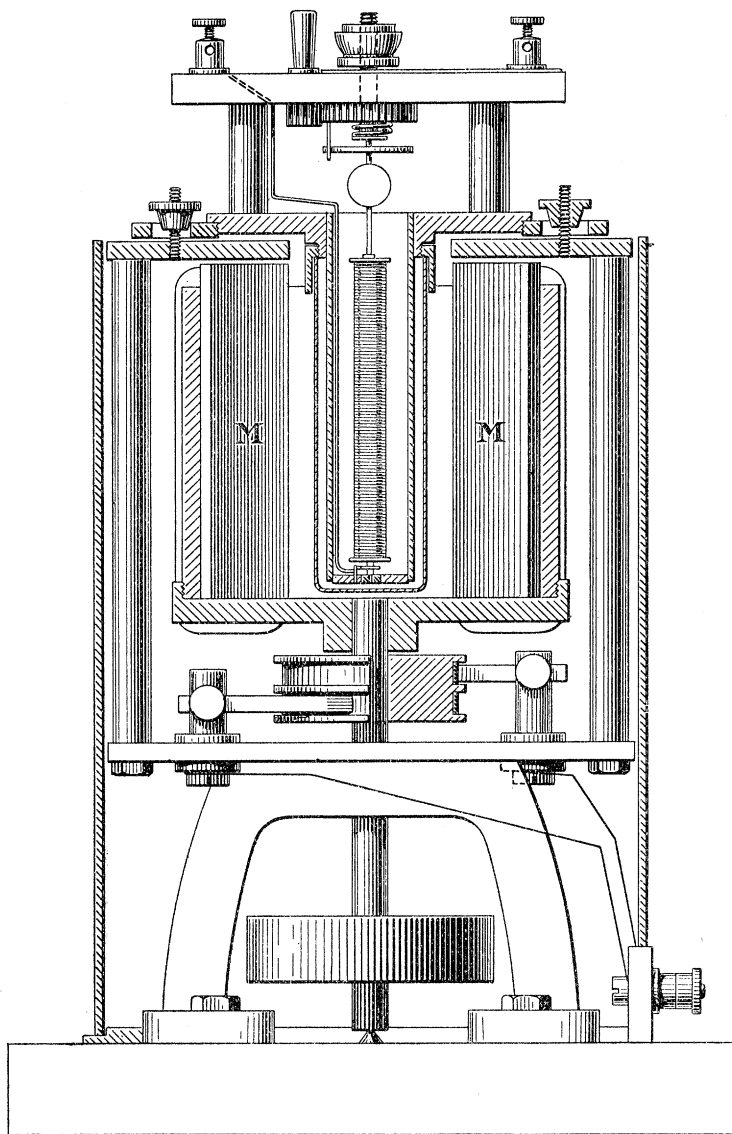
Owing to these encouraging results, it was decided to continue the experiments in this direction, abandoning the older form, in which a decrease of hysteresis was dealt with. The first bobbin constructed was about $\frac{5}{16}$ inch in external diameter, and had a vertical wire space of $\frac{1}{4}$ inch. The winding was a single No. 32-gauge iron wire, double cotton-covered, wound straight round from beginning to end. Later, No. 40 and No. 46 steel wires were employed, of which the latter gave the best results.

It was soon noticed that any method of increasing the oscillatory current in the wires, as by winding the bobbin with two wires having a slightly unequal number of turns, was of advantage in giving a larger deflection. Later a fine copper wire secondary, wound on the bobbin parallel to the magnetic wire, was tried, first with the ends insulated, and then with the ends soldered together. A marked increase in deflection was observed when the secondary was closed, showing that the magnetic nature of the wire itself was influential. Accordingly, a bobbin was then wound with insulated steel wire, doubled back on itself. This non-inductive winding gave by far the best results hitherto attained, and is now used, except when special results are required.

The instrument, though described as a detector of electrical oscillations, may be said to measure rather than detect, giving quantitative as well as qualitative results, and being capable of regulation from a sensibility of the same order as that of an average coherer down to practical insensibility to powerful sparks in the same room.

In the instrument, as shown in the figure, the electro-magnet takes the form of a ring capable of moving round a vertical axis, and is

provided on the interior with two long wedge-shaped pole-pieces, M, M, the current to the winding being supplied through brushes



bearing against insulated rings below. The magnet is made to revolve by an electro-motor, the best speed being about five to eight revolutions per second, but the electro-magnet may be replaced by a

permanent magnet system giving a similar field. A structure is built up, external to the magnet, to support the vessel containing the pivoted bobbin and its centreing arrangements. The bobbin itself is made of bone, and is about 2 inches long. It is provided with a steel spindle at each end bearing in a jewel hole, the two halves of the spindle being insulated from one another. The winding, which is, as far as possible, non-inductive, consists of about 500 turns of No. 46-gauge hard-drawn steel wire, insulated with silk. The bobbin is immersed in petroleum, or a mixture of petroleum with thicker mineral oil, which serves the double purpose of fortifying the insulation, and giving the damping effect necessary to steady the deflection due to the drag of the revolving magnet. Readings are taken by means of a spot of light, as with speaking mirror galvanometers, but a siphon-recording attachment has been fitted, and any form of contact for working a relay could be employed.

The detector, as before mentioned, gives quantitative readings, and, in some cases, the deflection may be too large to be easily read by the scale. For this purpose a variable shunt is provided, by which the deflection can be regulated.

For the purpose of wireless telegraphy, the instrument has the advantage of giving metrical effects. The benefit of this in facilitating tuning, and in other respects, need not be insisted upon.

From the physical point of view, the augmentation of hysteresis is interesting and unlooked for. It is probably to be ascribed to this, that the oscillatory circular magnetisation facilitates the longitudinal magnetising process, enabling the steel to take up a much larger magnetisation at each reversal than it would otherwise take, and thus indirectly augmenting the hysteresis to such an extent that the direct influence of the oscillations in reducing it is overpowered. The net result appears to be dependent on two antagonistic influences, and, in fine steel wire, under the conditions of our experiments, the influence making for increased hysteresis, as a result of the increased range of magnetic induction, is much the more powerful.

